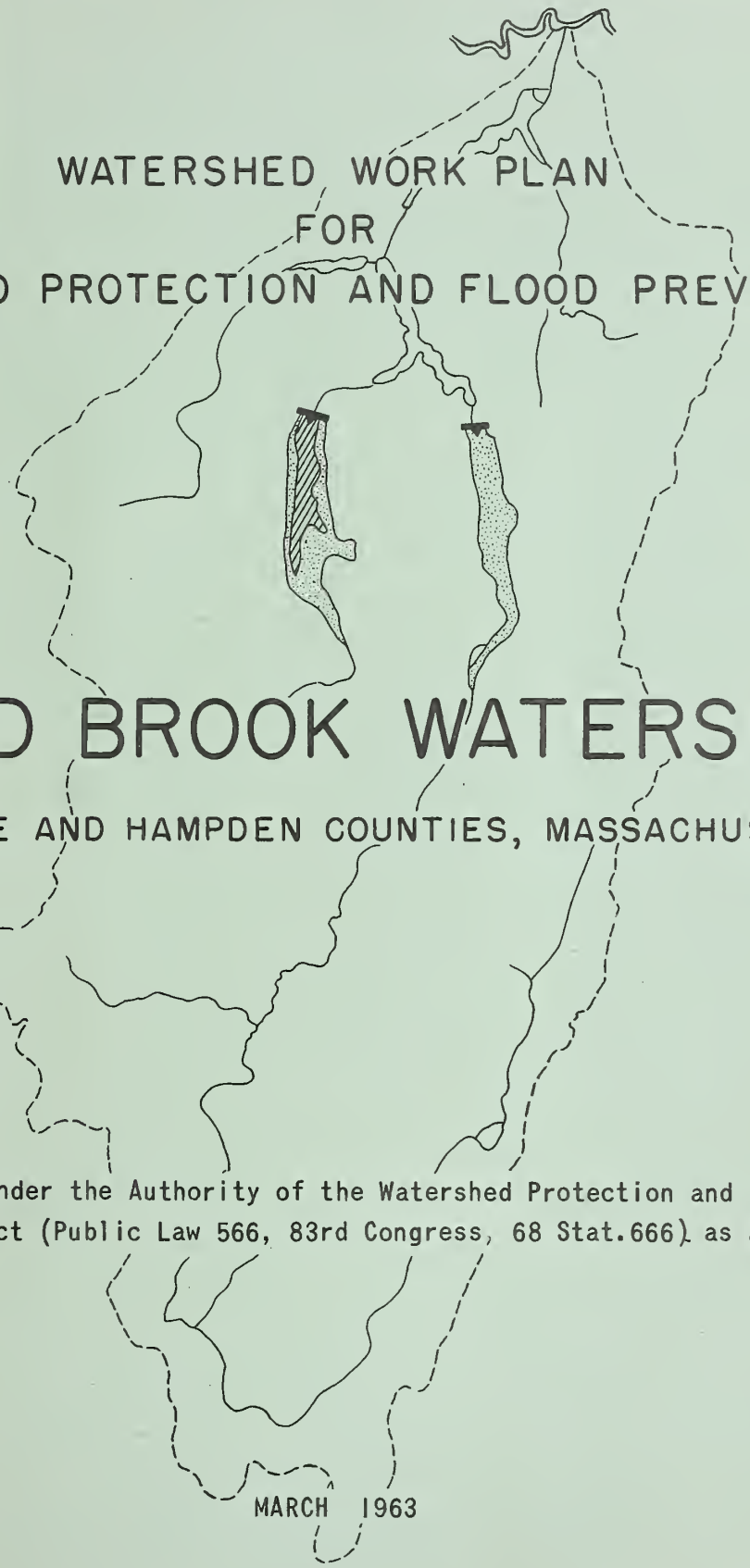
WATERSHED WORK PLAN
FOR
WATERSHED PROTECTION AND FLOOD PREVENTION



BROAD BROOK WATERSHED

HAMPSHIRE AND HAMPDEN COUNTIES, MASSACHUSETTS

Prepared under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat.666) as amended

MARCH 1963

WATERSHED WORK PLAN AGREEMENT

between the

Town of Easthampton
Local Organization

Hampshire Soil Conservation District
Local Organization

Hampden Soil Conservation District
Local Organization

(hereinafter referred to as the Sponsoring Local Organization)

State of Massachusetts

and the

Soil Conservation Service
United States Department of Agriculture
(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Broad Brook Watershed, State of Massachusetts, under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the Broad Brook Watershed, State of Massachusetts, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about 5 years.

It is mutually agreed that in installing and operating and maintaining the works of improvement substantially in accordance with the terms, conditions, and stipulations provided for in the watershed work plan:

1. The percentage of land, easements and rights-of-way cost as will be needed in connection with the works of improve-

ment to be paid by the Sponsoring Local Organization and by the Service are as follows: (The estimated land, easements and rights-of-way cost for the outlet works includes the cost of the collapsible dam.)

Works of Improvement	Sponsoring Local Organization (Percent)	Service (Percent)	Estimated Land, Easements & Rights-of-way Costs (Dollars)
Basic Recreation Development	50	50	32,300
White Brook Site	100	0	0
Summit Site	100	0	30,030
Dike	100	0	0
Outlet Works	100	0	18,750

2. The Sponsoring Local Organization will, without cost to the Federal Government bear the engineering, legal and administrative costs of acquisition of the lands, easements and rights-of-way as will be needed in connection with the works of improvement (estimated cost $14,990).

3. The Sponsoring Local Organization will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of works of improvement.

4. The percentage of construction costs of structural measures to be paid by the Sponsoring Local Organization and by the Service are as follows: (The estimated cost of the outlet works is exclusive of the cost of the collapsible dam.)

Works of Improvement	Sponsoring Local Organization (Percent)	Service (Percent)	Estimated Construction Cost (Dollars)
White Brook Site	3.60	96.40	88,466
Basic Recreation Facility	50	50	53,450
Summit Site	3.25	96.75	161,745
Dike	-----	100	12,185
Outlet Works	-----	100	231,500

5. The percentages of the cost for installation services to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (Percent)	Service (Percent)	Estimated Installation Service Cost (Dollars)
White Brook Site	-----	100	29,625
Basic Recreation Facility	50	50	10,690
Summit Site	-----	100	41,408
Dike	-----	100	4,325
Outlet Works	-----	100	44,874

6. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $2,500.)

7. The Sponsoring Local Organization will obtain agreements from owners of not less than 50% of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

8. The Sponsoring Local Organization will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

9. The Sponsoring Local Organization will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

10. The Sponsoring Local Organization will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

11. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.

12. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose.

    Where there is a Federal contribution to the construction cost of works of improvement, a separate agreement in connection with each construction contract will be entered into between the Service and the Sponsoring Local Organization prior to the issuance of the invitation to bid. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

13. The watershed work plan may be amended or revised, and this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

14. No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

Town of Easthampton

By /s/ Stanley Popielarczyk

Title Chairman

Date April 5, 1963

The signing of this agreement was authorized by a resolution of the Board of Public Works of the Town of Easthampton adopted at a meeting held on April 3, 1963.

/s/ Gretchen S. Belz

Date April 5, 1963

Hampshire Soil Conservation District

By /s/ Paul Micka, Jr.

Title Chairman, Board of Supervisors

Date April 9, 1963

The signing of this agreement was authorized by a resolution of the governing body of the Hampshire Soil Conservation District adopted at a meeting held on April 9, 1963.

/s/ George Buczala

Date April 9, 1963

Hampden Soil Conservation District

By /s/ George S. Hartley

Title Chairman, Board of Supervisors

Date April 9, 1963

The signing of this agreement was authorized by a resolution of the governing body of the Hampden Soil Conservation District adopted at a meeting held on April 1, 1963.

/s/ Nicholas Roselli
(Secretary, Local Organization)

Date April 9, 1963

Soil Conservation Service
United States Department of Agriculture

By _____
(Administrator)

Date _____

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WATERSHED WORK PLAN
BROAD BROOK WATERSHED
Massachusetts

SUMMARY OF PLAN

The plan was prepared by the Hampshire and the Hampden Soil Conservation Districts and the Town of Easthampton as the sponsoring local organizations. Technical assistance was provided by the Soil Conservation Service and the Forest Service.

The Broad Brook Watershed drains 7,578 acres (11.8 square miles). 4,726 acres are located in Hampshire County and 2,852 acres in Hampden County. All structural works of improvement are located within the Town of Easthampton, Hampshire County.

The "Diane" flood, August 18-19, 1955, caused direct damages in excess of $1,400,000. Three industries, three bridges and public utilities suffered severe damage. The destruction of bridges isolated sections of the Town of Easthampton. The loss of public utilities, especially water and sewerage disposal lines, caused a serious health problem. Industry suffered extensive sediment damage.

The estimated average annual direct and indirect damage from floodwater and sediment in the watershed under present conditions is $75,942. The project is expected to eliminate most, if not all, of these damages.

In addition to land treatment measures for watershed protection, the plan includes; one floodwater retarding structure, one multiple purpose floodwater retarding and recreation structure, a dike, and an outlet works.

The average annual flood prevention benefits from land treatment measures is $5,608 and $70,334 from structural measures. The benefits from the recreational development are $25,000 annually. The estimated average annual cost for installation of the structures including the recreational development is $32,398. The benefit cost ratio is 2.9 to 1.

The works of improvement are to be installed over a five year period at a total estimated cost of $900,377. The Public Law 566 share is $669,393. The balance of $230,984 is to be borne by other funds and includes: $92,910 for land, easements, and rights of way; $2,500 for administering contracts; $29,914 for construction; $5,345 for installation services; and $100,315 for land treatment measures.

The cost of land treatment measures is estimated to be $115,807 of which $100,315 is to be borne by other funds. $15,492 of Public Law 566 funds are to be used entirely for accelerated technical assistance. $9,292 is for the use of the Soil Conservation Service and $6,200 is for the use of the U. S. Forest Service.

The Summit Street structure is a single purpose floodwater retarding structure designed to permit the use of the top of the dam as a roadway. The White Brook structure is a multiple purpose floodwater

retarding - recreation structure. The two structures will control a total of 8.3 square miles (70%) of the drainage area, and provide storage for 2,232 acre feet of floodwater, 53 acre feet for recreational purposes and 30 acre feet for sediment.

The 810 foot dike provides protection for the water pumping station of the Town of Easthampton.

An outlet works on Lower Mill Pond, with a weir length of 100 feet reduces the tailwater elevation and increases the channel capacity at the main damage center.

The total installation costs of the structural measures is estimated to be $784,570 of which $658,840 is allocated to flood prevention and $125,730 to recreation. Public Law 566 funds will bear $653,901 and other funds will bear $130,669. This does not include the non-project cost of $5,258 for the additional width of dam to be used as a roadway.

The Town of Easthampton will be responsible for operation and maintenance of the structural measures at an estimated annual cost of $8,300. Land treatment measures will be installed, operated and maintained by landowners and operators under agreements with the Hampshire and the Hampden Soil Conservation Districts.

DESCRIPTION OF THE WATERSHED

Physical Data

The Broad Brook Watershed has a drainage area of 7,578 acres (11.8 square miles) all within the Commonwealth of Massachusetts. The major portion of the watershed lies within Hampshire County, with 2,852 acres in Hampden County. The area includes parts of the City of Holyoke and the Towns of Easthampton and Southampton.

Broad Brook originates in a sparsely settled section of the City of Holyoke and flows southerly three miles to the community of Rock Valley then northerly six miles through the Town of Easthampton to its confluence with the Manhan River. The major tributaries are White Brook and Wilton Brook. These drain into Nashawannuck Pond which in turn drains into Lower Mill Pond.

The major uses of land within the watershed are: Woodland, 3,865 acres or 51%; urban, 1,667 acres or 22%; grassland, 1,440 acres or 19%; cropland, 530 acres or 7%; and water, 76 acres or 1%.

The watershed is located in the Connecticut Valley section of the New England Physiographic Province. A small area in the southeastern portion of the watershed lies on the steep slopes of Mount Tom and East Mountain. The largest part of the watershed area, however, is almost flat lying, with very gentle rolling topography. Elevations

vary from about 130 feet mean sea level along the lower portions of the watershed to about 1,100 feet above mean sea level on Mount Tom.

The unconcolidated Pleistocene glacial lacustrine deposits cover most of the Broad Brook Watershed area. They consist of varved non-plastic silts, clays and very fine silty sands. Recent terrace deposits, consisting of sand and gravel, overlie the lacustrine sediments in a few areas. The underlying bedrock belongs to a Sugarloaf formation of Triassic Age and consists of arkosic sandstone with shaley and conglomeratic facies. The basaltic igneous rock of the same age outcrops in the area of Mount Tom. A major inactive fault is located near the southeasterly border of the watershed area.

Majority of the soils are droughty to well drained Hinckley, Merrimac, and Windsor. About 1 percent of the total watershed area consists of very poorly drained organic and mineral soils.

The watershed is in the Prevailing Westerlies zone. It lies in the path of extra tropical cyclonic storms that develop in the southwestern and central United States and travel northeasterly and easterly across the country. The area is also subjected to the occasional coastal storms including the tropical hurricane types that move up the Atlantic Coast. The devastating flood of 1955 resulted from storms of this type.

The area has annual temperature range between winters low of -15° to -25°F and the summer highs of 95° to 105°F.

The mean annual precipitation is 46 inches distributed quite uniformly throughout the year. (Annual runoff is 23 inches.)

Snows average from 45 to 60 inches and may occur in appreciable amounts from November to April.

The average growing season is about 148 days. The first killing frost occurs in the early part of October and the last killing frost usually occurring the early part of May.

Economic Data

Approximately 16,000 people reside within the watershed. Current reports indicate an increase of new residential building, expansion of industry, attraction of new industry, and a steady increase in population.

The floodplain of Broad Brook and its tributaries is used principally for industrial and agricultural activities. There are 42 farms within the watershed averaging 102 acres and having an average value of $30,037 (Comp. Agric. Stat. Data Mass.). Major crops grown are: (1) Forage for dairy production, (2) fruit, and (3) tobacco.

Approximately 62 percent or 2,400 acres of the forest land is farmer owned. The remaining 38 percent includes 240 acres of the state-owned, county administered, Mount Tom Reservation. It also includes 150 acres of forest land in Nonotuck Park, administered by the Town of Easthampton. Given protection, care and management, the forest stands are expected to contribute to the overall economy of the watershed.

Industry within the watershed is highly diversified with employment of 3,000 people and an annual payroll of $16,000,000. Manufacturers include, elastic webbing and braid, cut rubber thread, extruded rubber thread, raincoats, household waxes and polishes, cleaning compounds, and storage batteries.

Transportation facilities are excellent. Both the Boston and Maine and New Haven Railroads have freight service in the town. Passenger service and connections are available both in Holyoke and nearby Northampton. Major highways servicing the area are Route 10 and Route 141.

Utilities available include electric power, natural gas and oil.

WATERSHED PROBLEMS

Floodwater Damages

The "Diane" flood occurring in 1955, caused damages in excess of $1,400,000 within the Broad Brook Watershed. This storm caused major damages to three industries employing 800 people. Buildings were demolished. Raw materials, finished product, and plant machinery were damages or destroyed by floodwaters carrying sediment. The loss of three major bridges and public utilities affected all other industries. The total value of the property in the floodplain subject to damage is estimated to be in excess of ten million dollars. The destruction of bridges caused a number of sections within the Town of Easthampton to be completely marooned. The loss of public utilities, especially water and sewerage disposal lines, threatened a serious health problem within the community. Another major flood in 1910 caused considerable damages. Minor flooding largely associated with spring runoff occurs on the average of once in every ten years.

The major damage area is between Nashawannuck Pond and the Lower Mill Pond. The channel capacity through this area is restricted and effected by the backwater from the Lower Mill Pond because of the inadequate capacity of the outlet facilities.

The water supply pumping plant and well field above Hendrick Street is subject to damage. There were $13,000 in damage to these facilities in the 1955 flood.

Considerable floodwater damages occur below Ferry Street. This area is a common floodplain for Broad Brook and the Manhan Rivers.

Indirect damages were estimated to be 30 percent due to the highly industrialized urban area involved. These damages included losses of production, orders, good will, wages to employees, and the high cost of re-routing traffic.

Sediment Damage

Sediments carried by the floodwaters of 1955 were deposited in the factories and business establishments. The removal of these sediments was very costly. Many expensive industrial machines were ruined. These damages were included in the evaluation of floodwater damages. Siltation of Broad Brook during flood stages adversely effects the fishery habitat.

Erosion Damage

Erosion damage in the watershed consists primarily of sheet erosion. In 1955 a major slide occurred on the northwestern side of Mount Tom ruining a portion of Route 141.

Problems Relating to Water Management

The problems of agricultural irrigation and drainage are minor and the installation of these measures is being undertaken by the landowners under existing programs.

A population in excess of 100,000 people resides in an area within 5 miles of the watershed. This is a densely populated area and the people have considerable leisure time for recreational activities. The capacity of the present park facilities is inadequate.

There are several water based recreational facilities within one hours dri ing time from the area but because of the large population centers nearby such as Springfield and Holyoke, all present facilities are seriously over crowded. It is common for people to be turned away from the developments because they are full which is discouraging interest in outdoor recreation.

PROJECTS OF OTHER AGENCIES

The Massachusetts Department of Public Works constructed a "Bascule Gate" outlet to the Nashawannuck Pond in 1957 after the dam was breached in the 1955 flood. This installation was done in conjunction

with the repair of flood damages to Route 141. This outlet works is hydraulically operated to maintain a constant water level on the pond. As the pond level rises, the gate lowers allowing a greater discharge. This outlet work has virtually eliminated any flood storage effect in the Nashawannuck Pond, but it has provided protection from flood flows to the Route 141 bridge.

The U. S. Army Corps of Engineers, in its review of the Connecticut River Basin as part of the Northeast Flood Study Program, investigated the flood problem in the lower portion of Broad Brook below the Lower Mill Pond. This area is a common floodplain of the Broad Brook and the Manhan and Connecticut Rivers. The flooding in this area may be caused by water coming down Broad Brook, backing up from the Manhan River or both. Controls on the Broad Brook alone will not alleviate the entire problem. It would be necessary also to provide protection from the water backing up from the Manhan River. The Corps of Engineers considered the outlet structure at the Lower Mill Pond and a pressure conduit running from the Lower Mill Pond and through the railroad fill at the rear of the Hampden Mills factory facilities.

These proposals would relieve the flood problem to Ferry Street, the Hampden Mills factory facility, and the areas adjoining the Lower Mill Pond. This project was deemed economically unfeasible when the Hampden Mills vacated its factory facilities. However, it is entirely possible and should be considered that at some future date new industry will occupy these now vacated facilities. This could make this project economically feasible.

The outlet works to the Lower Mill Pond, as proposed in this work plan, would be harmonous with any future works in the area such as a pressure conduit and would be designed so that it would provide an inlet structure to a pressure conduit.

BASIS FOR PROJECT FORMULATION

The project objectives are to give each water resource problem the highest degree of solution practical within the limits of economic justification and the ability of non-Federal interests to meet their responsibility. The investigations described show the type and extent of works of improvement needed to provide for the objectives.

Consideration was given to controlling the floodwaters in the watershed to such an extent that a reoccurrence of the 1955 flood would not produce damages. This extent of control was not considered to be practical within the ability of non-Federal interest to meet their responsibilities. Protection of the major damage areas from a storm in excess of the 100 year frequency was considered to be adequate.

The water supply pumping plant and well field above Hendrick Street is the furthest upstream major problem area. Storage facilities to protect this area could not be economically justified. Diking these facilities was considered as an alternative and found to be feasible.

Another major problem area is bounded by Nashawannuck Pond on the upstream side and the Lower Mill Pond on the downstream side. The stream runs through one manufacturing facility and under three roadways. This limits the practical solution possibilities to storage reservoirs upstream or to outlet works downstream.

To obtain the highest degree of flood protection the storage structures are located as closely as possible to the problem area, and are designed to give the desired level of protection. The release rates from the floodwater retarding structures were selected to balance storage requirements with the channel capacities through the major problem area, and considered inflow below the controlled area.

The size and extent of the recreation development in association with the White Brook site was developed by the Massachusetts Water Resources Commission and the local Broad Brook Flood Control Committee.

The land treatment measures are to improve the hydrologic condition of the watershed and thereby reduce the flood runoff and sheet erosion.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

The land treatment measures as listed in Table 1 are practices effective in reducing runoff and erosion, increasing infiltration rates and water holding capacities. They contribute measurable floodwater reduction benefits by supplementing and supporting the structural program.

The installation of these measures will be accomplished by the accelerated land treatment program coordinated by the Hampden and Hampshire Soil Conservation Districts.

The following land treatment measures will be installed:

Cropland and Pasture Practices

Based on a survey of conservation needs made by the Hampshire and the Hampden Soil Conservation Districts, these measures will be installed on farm lands within the watershed.

1. Conservation Cropping Systems (300 acres)

   Growing crops in combination with needed cultural and management measures. This includes the use of rotations that contain grasses and legumes, as well as sequences in which the desired benefits are achieved without their use.

2. Cover and Green Manure Crop (400 acres)

   A crop of close-growing grasses, legumes, or small grain for summer or winter protection and for soil management occupying the land for one year or less, except where there is permanent cover as in orchards.

3. Strip Cropping, Field (25 acres)

   Growing crops in a systematic arrangement of strips or bands across the general slope to reduce water erosion. The crops are arranged so that a strip of grass or close-growing crop is alternated with a clean-tilled crop or fallow.

4. Pasture and Hayland Renovation (900 acres)

   Re-establishing the same or establishing other domesticated forage species on existing hayland or pasture land.

5. Pasture Planting (25 acres)

   Establishing adapted species of domesticated perennial, biennial, or reseeding forage plants on new pasture land converted from other uses.

6. Grassed Waterway or Outlet (5 acres)

   A natural or constructed waterway or outlet shaped or graded and established in suitable vegetation as needed for the safe disposal of runoff from a field diversion, terrace, or other structure.

7. Grade Stabilization Structure (No. 5)

   A structure such as a drop inlet, chute, or drop installed in a water course to stabilize the grade. Usually requires special designs, and may include flood-water detention capacity.

8. Streambank Protection (Ft. 2,500)

   Stabilizing and protecting banks of streams or excavated channels against scour and erosion by vegetative or structural means.

Forest Land Measures

The following remedial program has been developed by the local people from a statement of land treatment needs prepared by the Massachusetts Division of Forests and Parks and the U. S. Forest Service after a field survey of the watershed.

To insure proper forest land treatment and maximum watershed protection, forest landowners will be provided technical assistance for the following measures:

1. Tree Planting (50 acres)

   Artificial reforestation of certain open land is necessary to adjust land use with capability and to reduce runoff and erosion by developing a protective cover and an absorbent forest floor "sponge" of humus and litter. Under such conditions the soil is protected, infiltration rates improved, and soil moisture and storage capacity increased.

2. Hydrologic Cultural Operations (825 acres)

   These silvicultural operations are aimed at improving hydrologic conditions by manipulation of stand composition to create conditions favorable to the maximum production and protection of litter, humus, and forest cover. They include thinnings, weedings, salvage, and harvest cuttings.

3. Skid Trail and Logging Road Erosion Control (1 mile)

   The object of this measure is to divert water from eroding skid trails and logging roads in order to reduce runoff and control soil erosion and sedimentation. Simple water bars (ditches with pole or earthen diversions), spaced at specified intervals, are the usual means applied to slow down and divert water. Some eroding areas need revegetation to hold the soil in place.

Structural Measures

The plan includes one floodwater retarding structure, one multiple purpose floodwater retarding and recreation structure, one dike and an outlet structure. The White Brook structure will consist of two separate embankments. Locations of the proposed works of improvement are shown on the project map. The storage structures are designed to control the maximum 100 year frequency volume of runoff. The sediment storage allowance in the storage structures is based upon the estimated accumulation during the 100 year period. The elevation of the crest of the principal spillway will be based upon 50 year accumulation of sediments.

The storage structures have a total capacity of 2,315 acre feet, of which 2,232 acre feet are for flood storage, 30 acre feet are for sediment storage and 53 acre feet are for recreation storage. These structures control approximately 70 percent of the total watershed area. This floodwater storage capacity represents 5.0 inches of runoff from 8.3 square miles of drainage area controlled.

The dams will be of compacted earth fill construction. Principal spillways will be of reinforced concrete. Vegetative emergency spillways will be provided to insure the safety of the dams.

The total estimated installation costs for the two storage structures is $353,766.

The White Brook site has recreation water storage and recreation facilities associated with the site. There will be a lake with an area of 13 surface acres. The recreation facilities will be needed to realize the recreational use potential of the lake and will consist of (1) 3,500 feet of bituminous-concrete covered roadway providing access from the Summit Street area to the recreation area, (2) 3,000 feet of gravel road connecting the recreational areas on either side of the lake, (3) two parking lots, one on either side of the lake, to accomodate 150 cars, (4) 75 picnic tables, (5) four portable comfort stations, (6) one floating boat dock, (7) about 400 feet of beach along the lake, and (8) land, easements, and rights of way including flood easement of 53 acres, purchase of 40 acres and 30 acres of land already owned by the Town of Easthampton. The estimated installation costs for the recreational facilities is $117,180.

The purpose of the dike is to protect Easthampton's water supply pumping station from floodwaters coming from the upper reaches of Broad Brook. The borrow for the earth embankment of the dike will be removed from the channel side in such a manner to form a channel to pass the floodwaters from the Broad Brook. The total installation cost of the dike is $18,000.

The purpose of the outlet structure on the Lower Mill Pond is to increase the channel capacity through the major damage area located in the tail water area of the pond. It will function in conjunction with the upstream works to assure passage of retarded flow from the floodwater retarding structures and the runoff from the uncontrolled area. The present outlet structure has a weir 29 feet long. The water level is controlled by an arrangement of manually operated wooden flashboards. The proposed weir opening will be 100 feet long and 5.2 feet deep. The elevation of the crest of the weir will be controlled by a collapsible dam made of flexible material. This dam will control weir depths by being inflated or deflated automatically depending upon water heads. With the exception of the collapsible dam, the outlet works will be constructed of reinforced concrete. The total estimated costs for the outlet works is $295,624.

The total installation costs of all structural measures is $784,570.

Tables 1 and 2 show the costs and cost-sharing breakdowns for each structure. Flood prevention is the primary purpose of the storage structures, dike and outlet structure.

EXPLANATION OF INSTALLATION COSTS

The extent of the land treatment measures was derived from an inventory of the land treatment needs of the watershed and consider the portion of these needs which can be accomplished with a program of accelerated technical assistance. The installation costs of the land treatment measures was computed using unit prices which have been paid locally for installing these measures under similar conditions. The technical assistance costs is the assistance which will be necessary, beyond that presently available, to install the land treatment measures.

The total estimated cost of installing the structural measures includes construction, installation services, and other costs (see Table 1).

The construction costs are those costs associated with the actual construction of the structural works of improvement. The estimates were derived by developing preliminary designs of the structural works of improvement and assigning unit prices to the quantities as determined. Fifteen percent was added for contingencies on the storage structures and the dike. Twenty-five percent was added on the outlet works. The unit prices are based upon prices of construction of similar works in Massachusetts.

The installation services costs includes: (1) engineering field surveys, (2) geologic site investigations, (3) soil mechanics laboratory tests, (4) engineering designs, (5) layout, (6) supervision of construction, and (7) overhead. The cost of installation services for the basic recreational facilities was estimated as twenty percent of the construction cost.

The other costs are all of the additional costs associated with the installation of the structural works of improvement. This includes the estimated cost of the land, easements and rights of way and the cost of administrating the contracts for construction. The estimated costs of the land, easements, and rights of way include the value of land already owned by the Town of Easthampton.

A non-project cost will be the construction of 8 feet of extra width in the Summit Street site so that it may be used as a roadway. Any additional construction, such as paving or guard rails, necessary to complete the road is not considered as a part of this project.

The White Brook site will be constructed as a multiple purpose structure incorporating recreation with flood prevention. The structure will contain storage of 672 acre feet for floodwater, 53 acre feet for recreation and 10 acre feet for sediment storage. The Use of Facilities

Method was used to allocate the costs by purpose. 84 percent of the total installation cost will be allocated to flood prevention and 16 percent to recreation. Public Law 566 funds will provide 91 percent of the cost allocated to flood prevention and 43 percent of the cost allocated to recreation.

The following is an estimate of the total Public Law 566 and other obligations for each fiscal year during the installation period:

Year		Structural Measures	Land Treatment	Total
First	P. L. 566 Funds	$345,457	$ 3,098	$348,555
	Other Funds	78,849	20,063	98,912
	Yearly Total	424,306	23,161	447,467
Second	P. L. 566 Funds	276,374	3,098	279,472
	Other Funds	19,250	20,063	39,313
	Yearly Total	295,624	23,161	318,785
Third	P. L. 566 Funds	32,070	3,098	35,168
	Other Funds	32,570	20,063	52,633
	Yearly Total	64,640	23,161	87,801
Fourth	P. L. 566 Funds	---	3,099	3,099
	Other Funds	---	20,063	20,063
	Yearly Total	---	23,162	23,162
Fifth	P. L. 566 Funds	---	3,099	3,099
	Other Funds	---	20,063	20,063
	Yearly Total	---	23,162	23,162
Project Period Totals	P. L. 566 Funds	653,901	15,492	669,393
	Other Funds	130,669	100,315	230,984
	Grand Totals	784,570	115,807	900,377

EFFECTS OF WORKS OF IMPROVEMENT

The structural works of improvement will provide flood protection to six industries employing over 1,000 people, utilities, and three highway bridges.

The land treatment measures will reduce erosion and sedimentation, improve the water quality, prolong streamflow during droughts, help lower water temperature in the streams and ponds, improve the fishery habitant, provide marketable timber and provide for more efficient use of the agricultural lands. The land treatment measures will reduce the peak discharge by approximately 5 percent or 125 c.f.s. in the 100 year storm.

The proposed revisions to the outlet of Lower Mill Pond will provide for increasing the channel capacity at the main damage center from 1,150 c.f.s. up to 1,600 c.f.s. by reducing the tail water effecting the capacity of the channel.

The combined works of improvement will give 100 percent reduction of damages caused by a ten hour rainfall of 8.6 inches producing 6.8 inches of runoff. The runoff produced by this storm is in excess of the flow of the 1.0 percent chance of annual occurrence. The discharge developed by this storm at reach 2 will be reduced from 3,800 c.f.s. to 1,100 c.f.s. This provides a six foot reduction in water depth.

The Summit structure is so located that it could provide a second access to Nonotuck Park and a direct access to the new high school for the Holyoke Street area.

The dike at the water pumping station will protect this facility from floodwater damages in a 1.6 percent chance of annual occurrence storm. The floodwater storage area of the Summit site will back water over the dike on a 1.6 percent chance of annual occurrence storm. This will cause a 137 dollar annual induced damage. (This figure is shown as "Other Economic Costs" in Table 4.)

The "Diane" storm of 1955 produced 14.5 inches of rainfall in thirty hours with an estimated 7.5 inches of runoff from a ten hour period of rain. The works of improvement proposed are not intended to contain a storm of this extreme nature. A reoccurrence of this storm would result in emergency spillway flow but would not endanger the safety of the structures. The peak flow at the principal damage center would be reduced 21 percent by this project. The revised weir on Lower Mill Pond would lower the maximum stage in that pond five feet if the 1955 storm were to reoccur. The proposed structures reduce the peak flow sufficient to lower the maximum stage due to this storm a total of six feet. This elevation would be below the level of Ferry Street, preventing flow over the roadway.

The recreation water storage and associated recreational facilities will provide a source for outdoor recreation activities for 50,000 users annually. The boating, fishing, swimming, and picnicking afforded by the facility will provide an opportunity for local residents to spend their leisure in a healthful outdoor environment.

Remaining Damages

The works of improvement will not alleviate the floodwater damages in the area below Ferry Street caused by backwater. This area has been considered by the U. S. Army Corps of Engineers (see Projects of Other Agencies).

The discharge capacity of the principal spillway in the White Brook site will exceed the capacity of the culvert under the road immediately downstream.

PROJECT BENEFITS

The combined program of land treatment and structural measures will eliminate average annual damages attributable to Broad Brook in the major damage areas. Damages greater than the 0.5 percent chance event were not evaluated. These reductions are as follows:

	From	To	Percent Red.
Manufacturing	$56,159	0	100
Utility	1,468	0	100
Highway and Bridge	790	0	100
Indirect	17,525	0	100
	$75,942	0	

The use of the White Brook site for recreational purposes will result in $25,000 of annual recreation benefits.

The "Diane" storm of August 18-19, 1955, produced runoff considerably in excess of that expected from a 500-year frequency storm. Although some reduction would occur in stage from the "Diane" in the evaluation reaches, reduction in damage would not be great because of the type of property affected.

In addition to monetary benefits from flood prevention and recreation, the project will tend to improve public health, increase employment security, lessen hazard to life and provide a community sense of security. Secondary benefits will accrue from the increased demand for goods and services stemming from the installation of the project. These secondary benefits have not been used in project justification.

COMPARISON OF BENEFITS AND COSTS

The structural measures for flood prevention and recreation will be installed at an average annual cost $32,398. Primary average annual benefits of $95,334 will be provided by the project. The benefit-cost ratio is 2.9 to 1. Table 6 contains the benefit cost ratio by evaluation units. Works of improvement in each evaluation unit provides benefits in excess of costs.

PROJECT INSTALLATION

The Hampshire and the Hampden Soil Conservation Districts will assist landowners and operators cooperating with the district in the preparation and application of farm conservation plans. Before construction

begins on a structure, fifty percent of the land needing protection in the drainage area above will be under cooperative agreement with the Soil Conservation Districts. The Hampshire and the Hampden County Agricultural Stabilization and Conservation Committees will cooperate with the Soil Conservation Districts by selecting and providing financial assistance for those Agricultural Conservation Program practices which will accomplish the conservation objectives.

Technical assistance will be provided by the Soil Conservation Service for the installation of land treatment measures for watershed protection, including assistance needed for the development of basic conservation plans on farms in the watershed.

The forest land treatment measures will be installed by the landowners with technical assistance furnished by the Massachusetts Division of Forests and Parks in cooperation with the U. S. Forest Service. Individual management plans will be prepared for at least 45 forest landowners, outlining practical measures to be applied in the immediate future to maintain and improve the hydrologic condition of their forest land. Other technical assistance is needed to assure protection of watershed values and completion of the program. Included are supplemental activities such as developing timber sale or operating contracts, laying out skid trail and logging road systems, stimulation of landowner interest and participation in the program, and general planning and supervision of the program.

The land treatment measures are to be installed over a five year period.

The structural works of improvement will be installed over a three year period. The dike protecting the water pumping plant and well field, the Summit Street site and the White Brook site will be constructed during the first year. The outlet works to the Lower Mill Pond will be constructed during the second year. The recreation facilities will be constructed during the third year. The project structural measures are considered to be a single construction unit.

The Soil Conservation Service will provide the installation services to design, layout and supervise the construction of the flood prevention works of improvement. The Service will also provide the funds to pay construction costs allocated to flood prevention; half of the construction cost allocated to recreation; half of the costs for basic recreation facilities; and half of the cost for land, easements, and rights-of-way for the recreational development.

The non-federal cost for the installation of the basic recreation facilities will be provided by the Town of Easthampton.

The Town of Easthampton will obtain the land, easements, and rights of way necessary for the installation of the structural works of improvement. The Federal Government will pay half of the costs of the land, easements and rights-of-way for the recreational development.

The town will acquire title to the lands on which the structural works of improvement are located and any borrow areas needed to build them. The town will obtain flood easements, at least to the elevation of the crest of the emergency spillway, on all areas subject to inundation from the floodwater retarding structures. The town will obtain permits so that engineering surveys and geologic investigations may be conducted.

In the recreational development area the town will acquire fee simple title or perpetual easements for public recreational use the land above the storage pool up to an elevation two feet above the emergency spillway. Easements without provision for public recreational use will be acquired on 53 acres of lands lying upstream or otherwise so remote from the storage pool that they have no substantial value for public recreational use.

Water rights to the Lower Mill Pond are owned by the Hampden Mills. In lieu of purchase of these water rights for the operation of the outlet works to be constructed, the Town of Easthampton will construct a collapsible dam in the weir notch of the outlet structure. This will automatically control the water level of the pond and relieve the need for acquiring water rights to the Lower Mill Pond. There are apparently no other water rights which will be affected by planned works of improvement. However, if it is necessary to acquire any additional water rights, the Town of Easthampton will bear the cost of obtaining them.

Legislation has been filed with the Massachusetts General Court which will authorize the Massachusetts Water Resources Commission to administer the contracts for the construction of the structural works of improvement and provide for the Commonwealth to share with the Town of Easthampton in providing the money to carry out the non-Federal portion of this work plan.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out the works of improvement will be provided under the authority of the Watershed Protection and Flood Prevention Act, Public Law 566 (83rd Congress, 68 Stat. 666) as amended. The financial and other assistance to be furnished by the Federal Government in carrying out the project is contingent on the year by year appropriation of funds for this purpose by the Congress.

The non-Federal funds necessary for the installation of the structural works of improvement will be provided by the Town of Easthampton and the Commonwealth of Massachusetts on a cost sharing basis. The portion of the funds to be borne by the Town of Easthampton will be provided by adoption of an Article in the Warrant presented to the town meeting. The Massachusetts Water Resources Commission will assist

the Town of Easthampton in the preparation and filing of legislation with the Massachusetts General Court which will provide for the funds to be borne by the Commonwealth.

Landowners and operators will provide the funds for the installation of land treatment measures. The landowners and operators will have the opportunity to apply for cost-sharing benefits under the Agricultural Conservation Program for the installation and maintenance of the land treatment measures. In addition to the contribution made by the Agricultural Conservation Program, Federal-State Cooperative Forestry Programs, such as those authorized by the Clarke-McNary Act and the Cooperative Forest Management Act, will make substantial contributions to the program.

PROVISIONS FOR OPERATIONS AND MAINTENANCE

Land treatment measures will be maintained by the landowners or operators of the lands in cooperation with the Hampshire and the Hampden Soil Conservation Districts. Technical assistance and guidance will be provided by the Soil Conservation Service, and by the Massachusetts Division of Forests and Parks in cooperation with the U. S. Forest Service.

The Town of Easthampton will be responsible for operation and maintenance of all of the structural works of improvement including the basic recreational facility. The annual cost of operating and maintaining these works is estimated to be $8,300. The estimated annual operation and maintenance cost for each of the storage structures and the dike is $600. The estimated annual maintenance costs for the outlet structure is $1,200 which considers replacement of the collapsible dam every 20 years. The annual operation and maintenance cost of the basic recreational facility is estimated to be $5,300. Necessary funds will be provided through appropriations by the town.

An operation and maintenance agreement will be executed between the Town of Easthampton and the Soil Conservation Service prior to issuing the invitations to bid for the construction of the structures.

The operation and maintenance agreement will provide for inspections of the structural works of improvement to be made annually and after major storms. The Soil Conservation Service will provide at least one technical representative to accompany those making these inspections.

The structural works of improvement will be operated in such a manner that they will serve the purpose, both as to function and time, for which they are installed.

The maintenance will consist of but not be limited to the following:

1. Remove and burn debris.
2. Refill, smooth and vegetate rilling on embankments, spillways and drainage ways.
3. Realign disposal channels.
4. Repair damaged riprap, concrete or other works.
5. Repair fences and gates.
6. Maintain good sod covers.
7. Repair and replace collapsible dam and valve arrangements.

The Town of Easthampton will keep records of maintenance work performed and costs thereof, and report them annually to the Soil Conservation Service.

The town may charge an admission fee to the recreational facility provided the fee does not produce revenue in excess of the amortized initial investment and providing adequate operation and maintenance. The town will be required to establish a schedule of maximum admission or use fees which may be charged by private concessionaires where involved. The schedules of admission and use of fees together with other requirements for operation and maintenance of the recreational facilities must be mutually agreed to by the town and the Soil Conservation Service and set forth in the Operation and Maintenance Agreement.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Broad Brook Watershed, Massachusetts

Installation Cost Item	Unit	Number	Estimated Cost (Dollars) PL 566 Funds	Other Funds	Total
(1)	(2)	(3)	(4)	(5)	(6)
LAND TREATMENT					
Soil Conservation Service					
Conservation Cropping System	Acre	300		4,500	4,500
Cover and Green Manure Cropping	Acre	400		4,800	4,800
Strip Cropping	Acre	25		250	250
Pasture and Hayland Renovation	Acre	900		49,500	49,500
Pasture Planting	Acre	25		1,375	1,375
Grassed Waterway or Outlet	Acre	5		1,750	1,750
Grade Stabilization Structure	No.	5		3,000	3,000
Streambank Protection	Feet	2,500		2,500	2,500
Technical Assistance			9,292	2,640	11,932
SCS Subtotal			9,292	70,315	79,607
Forest Service					
Tree Planting	Acre	50		3,300	3,300
Hydrologic Cultural Operations	Acre	825		20,200	20,200
Skid Trail & Logging Road Erosion Control	Mile	1		300	300
Technical Assistance			6,200	6,200	12,400
Forest Service Subtotal			6,200	30,000	36,200
TOTAL LAND TREATMENT			15,492	100,315	115,807
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structure	No.	1	156,487		156,487
Multiple Purpose Floodwater Retarding and Recreation Structure	No.	1	85,277	3,189	88,466
Basic Recreation Facility	No.	1	26,725	26,725	53,450
Dike	Feet	810	12,185	--	12,185
Outlet Works	No.	1	231,500	--	231,500
Subtotal - Construction			512,174	29,914	542,088
Installation Services					
Soil Conservation Service					
Engineering Services			89,549	5,345	94,894
Other			36,028	--	36,028
Subtotal - Installation Serv.			125,577	5,345	130,922
Other Costs					
Land, easements and rights of way			16,150	92,910	109,060
Administration of Contracts			--	2,500	2,500
Subtotal - Other Costs			16,150	95,410	111,560
TOTAL STRUCTURAL MEASURES			653,901	130,669	784,570
TOTAL PROJECT			669,393	230,984	900,377
Summary					
Subtotal - SCS			663,193	200,984	864,177
Subtotal - FS			6,200	30,000	36,200
TOTAL PROJECT			669,393	230,984	900,377

Price Base 1961 March 1963

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION
Broad Brook Watershed, Massachusetts

(Dollars) 1/

Structure Site	Installation Costs - PL 566 Funds					Installation Costs - Other Funds					Total Inst. Cost
	Construction	Inst. Services		Land, Easements & R/W	Total PL 566	Construction	Inst. Services	Adm. of Contracts	Easements & R/W	Total Other	
		Engineering	Other								
White Brook	85,277	21,365	8,260		114,902	3,189		500		3,689	118,591
Basic Recreation Facilities	26,725	5,345		16,150	48,220	26,725	5,345	500	36,390	68,960	117,180
Summit	156,487	28,637	12,771		197,895	(5,258) 2/		500	36,730	37,230	235,175
Dike	12,185	3,181	1,144		16,510			500	990	1,490	18,000
Outlet Works	231,500	31,021	13,853		276,374			500	18,750 3/	19,250	295,624
GRAND TOTAL	512,174	89,549	36,028	16,150	653,901	29,914	5,345	2,500	92,910 4/	130,669	784,570

1/ Price Base 1961
2/ Cost of 8' of additional width of dam to be used as a roadway.
3/ Construction of collapsible dam.
4/ Includes $12,990 value of land already owned by the Town of Easthampton.

March 1963

TABLE 3 - STRUCTURE DATA
Broad Brook Watershed, Massachusetts

Item	Units	Summit	White	Total
Drainage Area	Sq. Mi.	6.1	2.2	8.3
Storage Capacity				
Sediment	Ac. Ft.	20	10	30
Floodwater	Ac. Ft.	1,560	672	2,232
Recreation	Ac. Ft.		53	53
Total	Ac. Ft.	1,580	735	2,315
Surface Area				
Sediment Pool	Ac.	5	2	7
Floodwater Pool	Ac.	94	93	187
Recreation Pool	Ac.		13	13
Volume of Fill	Cu. Yds.	120,994 2/	51,039 4/	172,033
Elevation Top of Dam	Ft.	194	194	
Maximum Height of Dam	Ft.	42	32	
Emergency Spillway				
Crest Elevation	Ft.	190	189	
Bottom Width	Ft.	350	150	
Type		Veg.	Veg.	
Percent chance of use		1	1	
Ave. Curve No. - Cond. II		70	70	
Emergency Spillway Hydrograph				
Storm rainfall	In.	11.2	9.5	
Storm runoff	In.	7.3	5.8	
Velocity of flow (Vc) 1/	Ft/Sec	3/	3/	
Discharge rate 1/	c.f.s.	3/	3/	
Max. W.S. Elev. 1/	Ft.	3/	3/	
Freeboard Hydrograph				
Storm Rainfall	In.	27.0	23.0	
Storm Runoff	In.	22.5	18.6	
Velocity of Flow (Vc) 1/	Ft/Sec	8.4	7.5	
Discharge rate 1/	c.f.s.	6,550	1,970	
Max. w.s. elev. 1/	Ft.	194	192.4	
Principal Spillway Capacity	c.f.s.	530	170	
Capacity Equivalents				
Sediment Volume	In.	.06	.09	
Detention Volume	In.	4.8	5.8	
Spillway Storage	In.	1.2	4.5	
Class of structure		C	C	

1/ Maximum during passage of hydrograph
2/ Including 8' of additional top width of dam for its use as a roadway
3/ Emergency spillway hydrograph is contained in floodpool
4/ Includes volume required for fill of both embankments

March 1963

TABLE 3A - STRUCTURE DATA, DIKE
Broad Brook Watershed, Massachusetts

Length of Dike	Volume of Fill	Drainage Area Above Dike	Top Width	Side Slopes	Maximum Height	Elevation Top Dike
Feet	Yard	Sq. Mi.	Feet		Feet	Feet
810	6,260	5.6	10	3:1	11.0	183.0

March 1963

TABLE 3B - STRUCTURE DATA, OUTLET WORKS
Broad Brook Watershed, Massachusetts

Number	Drainage Area	Design Weir Capacity	Materials		Height of Collapsible Dam	Length of Weir	Elevation Crest of Weir Notch
			Reinforced Concrete	Piling			
	Sq. Mi.	c.f.s.	Yard	Number	Feet	Feet	Feet
1	11.8	4,400	1,129	317	3	100	128

March 1963

TABLE 4 - ANNUAL COST
Broad Brook Watershed, Massachusetts

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost	Operation and Maintenance Cost	Other Economic Cost	Total
Evaluation Unit No. 1 Floodwater Retarding Structures Summit Street Multiple Purpose Floodwater Retarding Structure and Recreation Structure White Brook Outlet Works	23,411 2/	7,700	137	31,248
Evaluation Unit No. 2 Dike	550 2/	600		1,150
TOTAL	23,961	8,300	137	32,398

1/ Price Base - 1961
2/ Installation costs amortized 2 7/8% for 100 year period.

March 1963

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS
Broad Brook Watershed, Massachusetts

(Dollars) 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefit
	Without Project	With Project	
Floodwater			
Nonagricultural			
Manufacturing	56,159	0	56,159
Utility	1,468	0	1,468
Highway and Bridge	790	0	790
Subtotal	58,417	0	58,417
Indirect 30%	17,525	0	17,525
TOTAL	75,942	0	75,942

1/ Price Base - Long term prices as projected by Commerce Composite Index, ARS Price Projection, September 1957.

March 1963

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES
Broad Brook Watershed, Massachusetts

(Dollars) 1/

Evaluation Unit	Flood Prevention				Agr. Water Mgt.		Recreation	Other	Total	Ave. Annual Cost	Benefit Cost Ratio
	Damage Reduction	More Intensive Land Use	Changed Land Use		Drainage	Irrigation					
			Agr.	Urban							
Evaluation Unit No. 1 Floodwater Retarding Structures White Brook Summit Street Outlet Works	68,556						25,000		93,556	31,248	3.0 to 1
Evaluation Unit No. 2 Dike	1,778								1,778	1,150	1.5 to 1
TOTAL	70,334						25,000		95,334	32,398	2.9 to 1

1/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $5,608 annually.

March 1963

INVESTIGATIONS, ANALYSES, SUPPORTING TABLES AND MAPS

LAND TREATMENT MEASURES

Total land treatment needs have been estimated by work unit personnel by studying aerial photographs of the watershed and by ocular observation of most of the land currently in farm crop production. The total program planned for installation over the five-year period was based on estimates of what the cooperators would accomplish if adequate technical assistance were available giving due consideration to the added stimulus from the watershed project. The acreage, number of cooperators and number of basic plans in the watershed area were prorated against the totals for the Soil Conservation Districts to determine the level of the going program in the watershed.

The difference between the planned program and the going program determined the accelerated program which is included in this work plan. Technical assistance needed for the accelerated program was determined by using current work unit rates for planning and application activities.

ECONOMICS

Basic information was obtained from personal interviews with property owners and recorded on flood damage schedules. The information obtained was adjusted to reflect the dollar damage caused by a reoccurrence of a storm of the intensity of the "Diane" 1955 hurricane. A comprehensive investigation was conducted with all property owners subject to flood damage being contacted.

Damages were appraised by one foot increments to an elevation three feet above the elevation of the key flood "Diane", August 18-19, 1955, and below to the elevation where damage no longer exists. These damage estimates were tabulated by stage for each reach and based on long term construction indices. Reaches were established for their hydraulic as well as stage damage uniformity.

Indirect damages were estimated to be 30 percent of the direct due to: (1) loss of production due to power failure, and curtailment of transportation facilities, (2) loss of wages due to disruption of manufacturing operations, (3) costs of rerouting traffic, and (4) affects on other industries outside of the floodplain.

Evaluation

The frequency method on Page 21 in Chapter 3 of the Economics Guide was used to compute average annual damages and benefits.

Manufacturing, highway and bridge and utility damages were tabulated for each evaluation reach. These were evaluated up to a .5 percent chance of occurrence storm.

The two storage structures and the outlet structure were evaluated as one unit due to their interdependence to a common damage center.

The dike at the Easthampton water pumping station was evaluated as one unit as it affords protection to this area alone.

Easement costs were estimated by the local sponsors based on current market values. These appraisals were made by local realtors and concurred in by the Service.

Benefits from enhanced use of the floodplain were considered, but eliminated due to the limitations of the floodplain.

The benefits for the recreation facility were computed by estimating the number of annual user-days and multiplying by $0.50. The annual user-days were estimated to be 50,000 by analyzing the present use of Nonotuck Park and Mt. Tom Reservation.

All costs incurred during the project installation are based on current prices.

All costs were amortized at 2 7/8% for a 100 year period.

HYDRAULICS AND HYDROLOGY

The rainfall vs. frequency relationships used in the development of this work plan were obtained from U. S. Weather Bureau, Technical Paper No. 29. Present and future soil-cover complex curve numbers were developed from information furnished by the Soil Conservation Service and the U. S. Forest Service. Soil and cover data was gathered for two sub-areas, the hilly, Mount Tom slopes and the valley floor. The curve numbers computed for these two regions were so nearly alike that one verage curve number was used for the whole watershed. A III antecedent moisture condition was used in determining the runoff relationships. The A.M.C. of III was used when a study of the region revealed that freshets occur either during a long duration storm or a storm occuring on frozen ground. Runoff vs. frequency relationships for a 10 hour storm duration evaluation series were determined using the above data with the tables in Technical Release No. 16.

A relationship of head required vs. discharge capacity was developed for reach 1 using the formulas; $q=CLH^{3/2}$, $q=CA(2gh)^{1/2}$, and Mannings' formula. Since the elevation vs. discharge relationship in this area is regulated by the water surface elevation in Lower Mill Pond, the present rating curve was developed using the parameters of; peak dis-

charge developed by percent chance of occurrence runoff, head required to pass this discharge, tail water elevation, and percent chance of occurrence of tail water elevation as determined by flood routings through the pond. The rating curve for reach 2 was developed using the formula, $q=CLH^{3/2}$, with the coefficient for the Bascule Dam as supplied by the manufacturer. Six water surface profiles were computed through reach 3 using the "Step Method" described in Chapter 3.14 of Section 4-A, Hydrology, of the National Engineering Handbook (NEH-4A), to develop the rating curve for this reach. Field surveys were made of all cross-sections used with the exception of the Bascule Dam where the design specifications were used.

The watershed was divided into nine-sub-watersheds. The time of concentration and stream travel times were computed for each sub-watershed by use of the stream hydraulics, as described on page 3.15-3 of NEH-4A. Synthetic, triangular, unit hydrographs were developed for each sub-watershed using equations 4, 7, and 14 of Chapter 3.16, NEH-4A. These hydrographs were stream routed, using the "Wilson" Method as outlined on page 3.17-19, NEH-4A, to the downstream end of the watershed. The new Bascule Dam at Nashawannuck Pond is designed to operate with a constant water surface elevation permitting no live storage in the pond. No lag time was used in routing the storm through this pond. With the peak flows from this routing and the runoff vs. percent chance of occurrence curve, peak discharge vs. percent chance of occurrence curves were drawn for the three damage areas.

The stage vs. discharge relationship for the outlet of Lower Mill Pond was computed using the formulas, $q=CA(2gh)^{1/2}$ and $q=CLH^{3/2}$. The stage vs. storage curve for the pond was also developed. The one, three, and five inch runoff storms were routed through Lower Mill Pond using the "storage-indication" method presented in Chapter 3.17 of NEH-4A. The maximum water surface elevations were related to percent chance of occurrence for use in determining the rating curve for reach 1.

The effect of the land treatment measures upon peak flows was computed using the change in soil-cover complex curve numbers by the procedur described in E&WPU Memorandum No. 34, Hydrology No. 3.

The 0.5 and 0.1 percent chance of annual occurrence runoffs, as determined from the evaluation series, were routed by the "storage-indication" method through the proposed floodwater retarding structures. The outflows were then routed through the damage areas and Lower Mill Pond considering the improved outlet works proposed. It was determined from these routings that the peak flows are within channel banks.

The key storm, "Diane", August 18-19, 1955, was reproduced using available storm reports. Sub-watershed hydrographs were developed using equations 4, 7, and 8 of section 3.16, NEH-4A, and adding incremental hydrographs. These hydrographs were routed through the

watershed using Wilson's method and the "storage-indication" method in the same manner as the synthetic storm. These routings confirmed the storm data as determined by interviews. This storm was also routed through the proposed floodwater retarding structures by the storage-indication method to determine the safety of the structures. This storm would cause emergency spillway flow in both structures to about 2 feet below the top of the dam. At the principal damage center, the structural measures would reduce the peak discharge from 5,000 c.f.s. to 3,900 c.f.s.

GEOLOGY AND SEDIMENTATION

Preliminary geologic investigations were made on each of the proposed floodwater retarding structure sites. Numerous hand auger holes were drilled at and near the proposed sites. Samples were taken to the laboratory and grain size distribution curves were obtained by sieving the materials.

No adverse geologic problems were encountered. Adequate borrow material for the structures is available within a reasonable distance from the sites. The sediment storage requirements for the floodwater retarding structures were computed and since most of the sediments are derived from the sheet erosion, Musgrave formula has been used in order to compute soil loss.

Sediment storage will contain the expected sediment accumulation at the reservoir for a 100 year period.

Both proposed sites have similar geologic conditions. They occupy "U" shaped valley deeply incised into the lacustrine deposits of silty sands, silts, and clays. The abutments of both sites consist primarily of very fine silty sands and non-plastic and varved silts and clays. Swampy conditions located at the valley bottom conform about 3 feet of organic muck. Abutment seepages in the form of springs were located on both sites. Bedrock does not outcrop at or near the sites. The water wells drilled in the vicinity of both sites revealed the bedrock to be over 100 feet below the surface.

Principal spillway foundations will consist of lacustrine deposits of varved silts and clays. It is possible that compressibility and strength of these deposits may require intense investigation.

No rock excavation is anticipated in the emergency spillway areas.

Borrow materials will consist of lacustrine deposits of very fine silty sands and non-plastic, varved silts and clays.

The proposed dike is located in the southern portion of Broad Brook. The geologic conditions in the area are similar to those found at the

floodwater retarding structure sites. The foundation consists of very fine silty sands underlain by deposited silts and clays. The borrow material will come from the excavation of the channel along the dike. No rock excavation is anticipated during the channel excavation.

The concrete outlet structure is situated in the lower portion of Lower Mill Pond. Soil and foundation investigation performed in 1956 in conjunction with a construction of the bascule gate located on Nashawannuck Pond revealed about 50' to 60' of very soft lacustrine deposits of silt and clay. Similar foundation conditions are expected to be present at this location which would require very extensive investigation.

A detailed site investigation will be made at each site prior to final design of the structures.

PRELIMINARY DESIGNS AND COST ESTIMATES

The latest available U.S.G.S. 7 1/2 minute quadrangle sheets were used to determine possible locations for storage structures and to develop preliminary stage-storage curves for each site. This data was used on a field reconnaissance of each site to determine tentative feasibility and survey requirements.

The floodwater detention and principal spillway capacity requirements were determined by the method presented in Technical Release No. 10. The Summit Street site has storage limitations which determined the required principal spillway capacity. The principal spillway capacity for the White Brook site was determined by the channel capacity of the major damage area downstream of both structures. This capacity controlled the storage requirements for the site.

The emergency spillway design hydrographs were computed using the minimum criteria set forth in Engineering Memorandum SCS-27, and the method described in Section 3.21, NEH-4A.

The size of the emergency spillways was determined by computing a storage-indication routing through the structure using Hp vs. discharge per foot of bottom width information obtained from Technical Release No. 2. The freeboard hydrograph was used in this routing since it was determined that the emergency spillway hydrograph was contained below emergency spillway crest.

Topographic maps were developed for each structure site by field surveys using a plane table and telescopic alidade. Final stage-area and stage-storage curves were developed from these maps. Preliminary designs of each storage structure were made using the topographic maps, stage-storage curves, storage requirements and the geologic site

condition information. Preliminary design quantities were determined for five items; embankment, principal spillway, clearing, clearing and grubbing, and seeding. The volume of embankment was determined by the end area method, using the centerline profile from the topographic maps and stripping depths recommended by the geologist. The clearing, clearing and grubbing, and seeding quantities were determined by measuring the plan view of the designs.

Cost estimates were computed for the floodwater retarding structure and the multiple purpose floodwater retarding-recreation structure applying unit costs to quantities determined in the preliminary design. The unit costs were developed from an analysis of bids on construction of similar structures in Massachusetts. A contingency item of 15 percent was added. Installation services and other installation costs were estimated on an individual structure basis using experience gained in construction of other Public Law 566 projects in the Northeast.

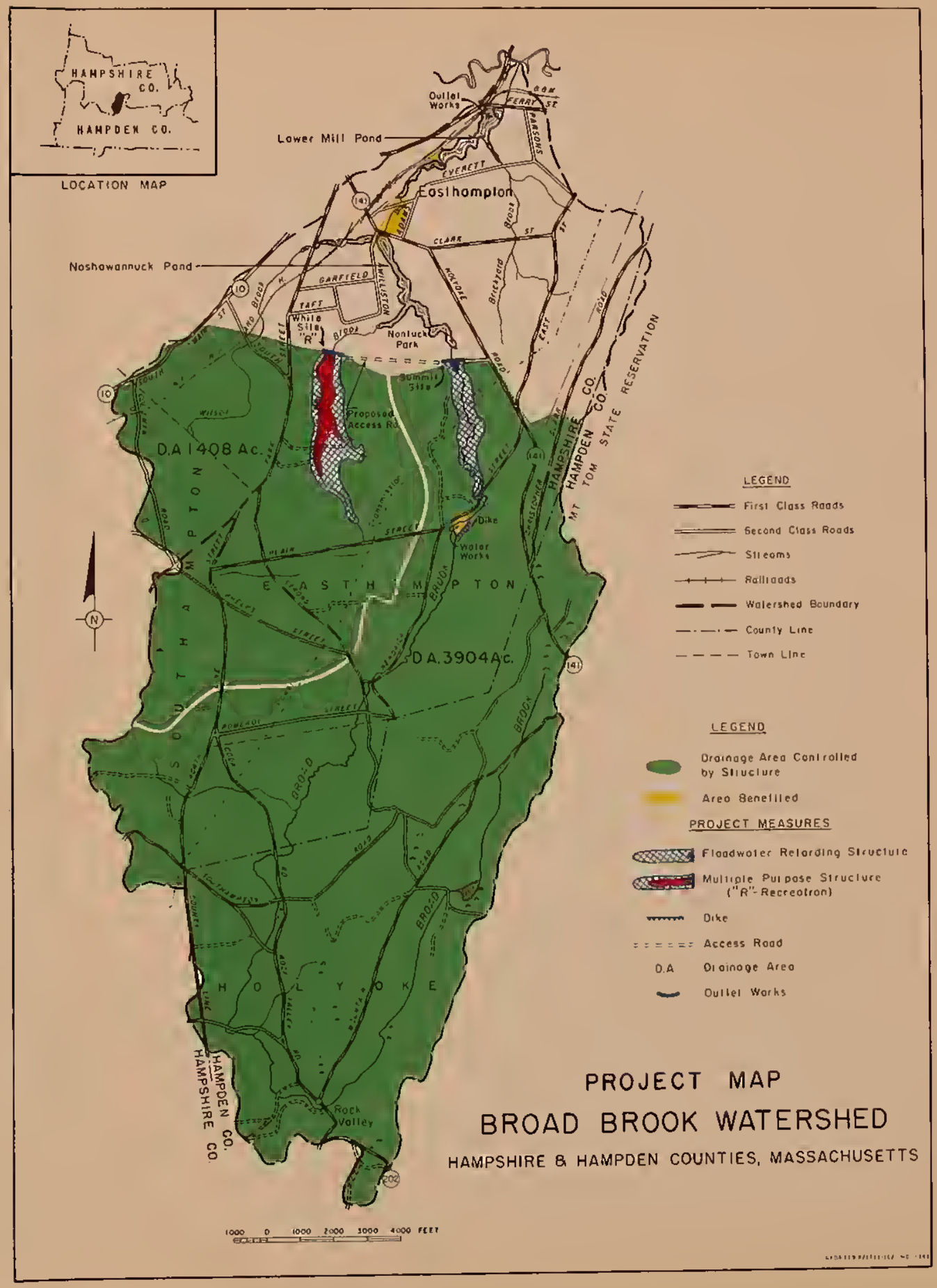
The design of the roadway for access to the recreation facility was based upon similar roads used in the area for this type of use. The cost estimate was based upon a similar road recently constructed in Easthampton. A contingency item of 12 percent and an installation services item of 20 percent were added to the basic construction cost to arrive at the total estimated cost.

The dike design was based upon a topographic field survey of the area by plane table and telescopic alidade. The top elevation was set by designing a structure which would intercept and pass the headwaters safely past the pumping facility. Two feet were added for freeboard to minimum design elevation. The design includes an outlet pipe with a flap gate to release any water accumulation behind the dike. The borrow area to build the dike would come from the right hand side as you look downstream. The minimum cross section of the borrow removal should be sufficient to pass the design flow of 1.6 percent chance of annual occurrence.

The cost estimate for the dike was accomplished in a manner similar to the cost estimates for the storage facilities previously described.

The outlet works to the Lower Mill Pond were designed to provide relief from tail water at the main damage center. The design capacity of the weir was based upon the standard weir formula, $Q=CLH^{3/2}$. The preliminary design considered a massive reinforced concrete Ogee weir with piling supporting the foundation.

The cost estimate of the outlet works was computed by applying unit costs to quantities determined in the preliminary design. A contingency item of 25 percent was added, along with installation services and other installation costs.



PROJECT MAP
BROAD BROOK WATERSHED
HAMPSHIRE & HAMPDEN COUNTIES, MASSACHUSETTS